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TO STUDY ON BEHAVIOR OF CORBEL WRAPPED WITH FRP SHEET UNDER MONOTONIC LOADING

Mr. Bande Vidhyasagar.N[1], Prof. Vijaykumar Bhusare[2], Prof.Borude.B.G[3], Prof.Patil.S.S[4].

[1]PG Student, Department of Civil Engineering, Imperial College Of Engineering and Research, Wagholi, Pune, India.
[2]Assistant Professor, Department of Civil Engineering, Imperial College Of Engineering and Research, Wagholi, Pune, India.
[3,4]Assistant Professor, Department of Civil Engineering, Shree Ramchandra College of Engineering, Lonikand, Pune, India.

Abstract - *The Moto of upgrading the existing civil engineering structures has been one of great importance for over years. Degradation of bridge decks, girders, beams and columns, parking structures, buildings and others may be attributed to ageing, environmentally affected degradation, poor design or construction, lack of maintenance and too many accidental events such as earthquakes.*

Composite structures are said to as structures built up by structural self-carrying sub element by shear connectors to from an interacting unit. Composite structures have proved widespread use in recent decades because of the benefits of combining the two construction materials.

It is now generally recognized that the use of Fiber Reinforced Plastic (FRP), externally bonded reinforcement, is a practically efficient and technically sound method of strengthening and upgrading structurally inadequate or otherwise damaged or deteriorating load bearing members

***Key Words*: Corbel, Strut and tie method, FRP, Monotonic loading, Load-deformation curve, etc**.

1. INTRODUCTION

In recent years, there has been an increasing effect in India to provide adequate civil engineering infrastructures for boosting the economic growth and development of the country. In the process of development, construction of new infrastructures has always attracted greater attention. However, the maintenance and retrofitting of existing infrastructure has also become increasingly important mainly due to the earthquake disaster everywhere in the world and more so in India.

Corbels: Corbel or bracket is nothing but a short-cantilever used to support the reinforced concrete beam element. Corbel is structural element mostly used for support the pre-cast structural system such as pre-cast beam and pre-stressed beam. Mostly the corbel is casted with the column or wall element.

This chapter is describes the design procedure of corbel or bracket structure. Since the load from pre-cast structural element is heavy than it is very important to make a good detailing in corbel.

Behavior of Corbel:

The followings are the major items show the behavior of the reinforced concrete corbel, as follows:

1. The shear span/depth <1.0; it makes the corbel behave in 2D structure.
2. Shear deformation is dominant in the corbel.
3. There is large horizontal force transmitted from the supported beam result from long-term shrinkage and creep deformation.
4. Bearing failure due to large concentrated load.
5. The cracks are usually vertical or inclined pure shear cracks.
6. The way of failure of corbel is: yielding of the tension bar, failure of the end anchorage of the tensile material, failure of concrete by compression or shearing and bearing failure.

Fiber Reinforced polymer (FRP):

Now days, there has been considerable worldwide attentions of all the engineers for the fiber reinforced polymer (FRP) material in industry. The properties these materials are 1.more strength to weight ratio, 2.effective resistance to corrosion, 3.chemical resistance, 4.electrically non-conducting, 5.light-weight and also twice to four times as strong as steel in tension. Comparatively it is easy to use, fast, and results in small changes in structural size generally in the order of millimeters. it is expected to replace most of previous existing repairs and strengthening techniques. Because these materials can be applied while the structure is in use also.FRP composite materials are made up of fibers (e.g. glass, carbon, Kevlar, etc.) bonded together with a resin matrix. For the composite materials discussed here, the fibers are long and continuous.

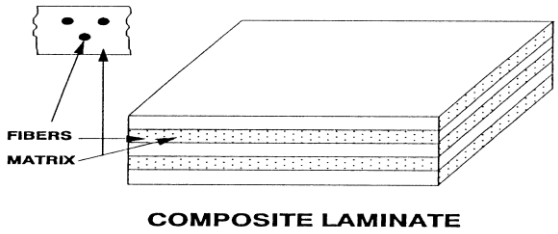


Fig. 1: Composite laminate and its Constituents

Objectives:

1. To examine experimentally the behavior of RC corbel using externally bonded Glass FRP sheets under monotonic loading.
2. To examine failure pattern of corbel

Methodology:

1. *Material information and preliminary test.*
   There are three types of fiber which is mostly used for confinement. Their name and major properties are as follows

Properties of FRP:

The main properties of Carbon, Aramid and E-Glass fibers are given in Table1.

Table 1: Properties of FRP

Sr. No.	Property	Type of fiber		
		Carbon	Aramid	E-Glass
1	Tensile Strength (MPa)	4300 - 4900	3200-3600	600 - 1800
2	Modulus of Elasticity (GPa)	230 - 240	124 – 130	55 - 70
3	Strain at failure (%)	1.9 - 2.0	2.5 - 2.8	3.2 - 3.6
4	Specific gravity	1.76 - 1.78	1.44 - 1.46	2.56 - 2.58
5	Poisson's ratio	0.2	0.35	0.2
6	Density (kg/m^3)	1800	1440	2560

2. Experimental Program

Corbels were designed, so they are failed in flexure and strong in shear. To improve the capacity or performance level of a corbel, it is necessary to strengthen or retrofit the corbel in flexure. To improve the flexural strength, corbel were retrofitted at bottom and side face by using GFRP material. To achieve the required aim, the experimental program has been made. Designed corbel were cast. These corbels were classified into different groups. Out of these groups, first group was made of control beams.

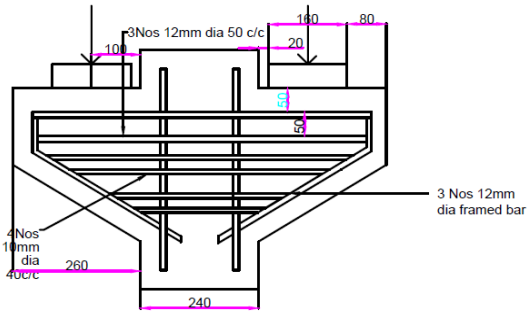


Fig.2.Design parameter of corbel

The two control unplated corbel (CC) failed at an ultimate load. Then take the average load of these corbels as the ultimate load. The corbels failed in conventional ductile flexure with yielding of the tension steel, followed by crushing of the concrete in the compression zone.

Mix Design:

The bureau of Indian Standard, recommended a set of procedure for design of concrete mix, mainly based on the work done in national laboratories. The mix design procedure is covered in IS: 10262:2009. The method given can be applied for both medium strength and high strength concrete.

2.1. Nomenclature of specimens

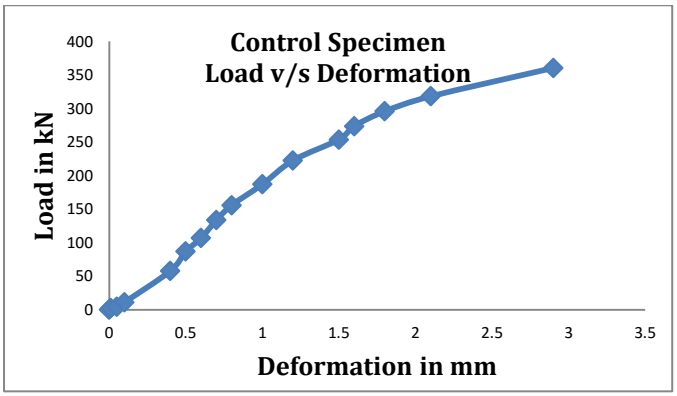
The test specimens were divided into five groups including control beam group. Remaining four groups were classified based upon the wrapping technique, and material used for wrapping.

Table.2.Nomenclature of corbel.

Sr.No.	Nomenclature	Descriptions.
1	NC/CC	Normal Specimen/Control Specimen
2	HCFRP	Corbel wrapped with carbon sheet in Horizontal manner
3	HGFRP	Corbel wrapped with Glass sheet in Horizontal manner
4	DCFRP	Corbel wrapped with Carbon sheet in Diagonal manner
5	DGFRP	Corbel wrapped with Glass sheet in Diagonal manner

3. Result and Discussion

The testing of corbel is carried out in College of Engineering Pune consist of The oldest UTM machine Having capacity 1780KN.The readings are in the form of pounds and dial gauge ranges from 0-12.7mm.having list count 0.01mm and following results are obtained:



Graph.1. Load V/S Deformation for Control Specimen.

Fig.3 Failure Pattern

3.1 Failure of corbel.

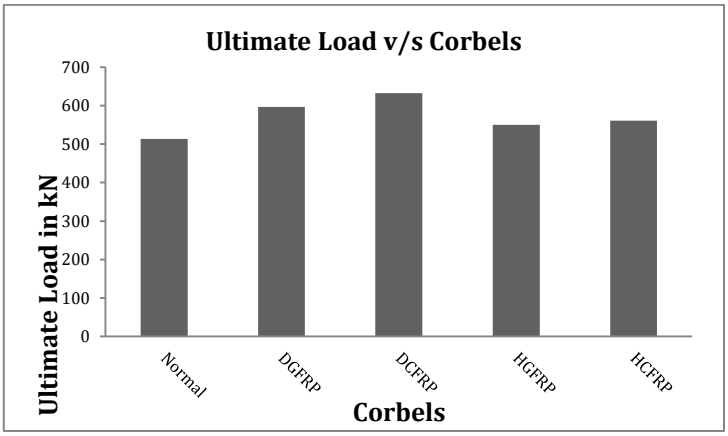
Basically the failure type of corbel is shear failure i.e.daigonal shear failure. The first crack was developed in diagonal manner from face of loading point. Finally at failure point load the concrete get crushed and splitting of specimen had been happened

3.2. Discussion on test result.

a. Load carrying capacity of corbels.

The graphical discussion on Ultimate load v/s corbels concluded following result.

1. The control specimen has 513.191kN failure load which is more than first crack load.
2. The load capacity is more when corbel is wrapped with carbon fibre as compared to glass fiber.
3. When the corbel was wrapped with carbon fiber ultimate load was found as 632.248kN.for diagonal wrapping and 560.476kN for Horizontal wrapping.i.e. The load carrying capacity is increased compared to control specimen for carbon fibre wrapping, 23.2% for diagonal wrapping and 9.2%for horizontal wrapping.
4. When corbel was wrapped with glass fibre ultimate load was found to be 596.907kN for diagonal wrapping and 549.867kN for horizontal wrapping. I.e. Glass fibre wrapping increases ultimate load compared to control specimen, 16.3%for diagonal wrapping and 7.1%for horizontal wrapping.



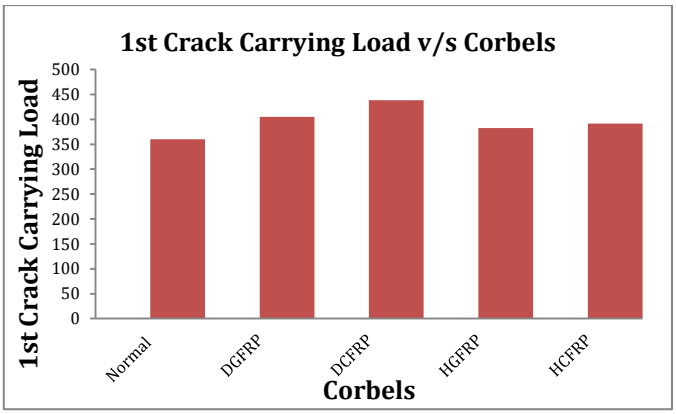
Graph.5.Ultimate Load v/s Corbels.

b. 1st Crack Carrying Capacity of Corbel.

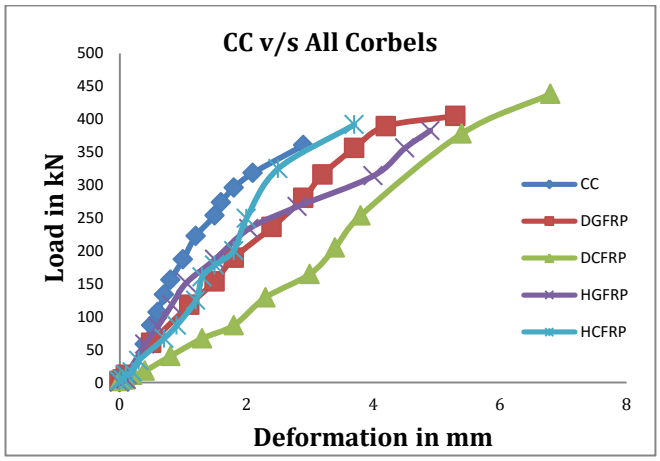
On discussion of the graph plotted between crack carrying capacity and corbels following observation are carried out.

1. The First crack carrying capacity of control specimen of corbel is 360.306kN, which less than Ultimate load carrying capacity by 42.4%.

2. The graph shows different types of specimen with their First crack point. It is found that the first crack point was observed at 360.306kN for control specimen of corbel but this load carrying capacity increased due to application of Glass FRP as 404.788kN in diagonal wrapping and 382.547kN in Horizontal wrapping also for Carbon FRP 438.15kN in diagonal and 391.444kN in Horizontal wrapping.



Graph.4.1st Crack Carrying Load v/s Corbels.



Graph.4.Comparision between CC v/s Corbels.

4. CONCLUSION

Based on this work following conclusions are made:

1. The failure observe in corbel is diagonal shear failure for control specimen.
2. The load carrying capacity is increased compared to control specimen for carbon fiber wrapping, 23.2% for diagonal and 9.2%for horizontal wrapping.
3. Glass fiber wrapping increases ultimate load compared to control specimen, 16.3%for diagonal wrapping and 7.1%for horizontal wrapping.
4. The results show that the CFRP strips can delay the formation of first crack .This delay is mainly depending on the CFRP existence near the weak points (i.e. corbel column junction) and the amount of CFRP in the specimens. This is due the high moment at this point.
5. The developed cracks are shear crack began to develop at the loading area from the end of the bearing plate continuing toward the corbel face with an angle varied from 40 to 60 degrees.
6. The load capacity is more when corbel is wrapped with carbon fiber as compared to glass fiber.

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